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RESEARCH ARTICLE

The Prognostic Power of Albumin: A Key to Mortality Prediction in Open-heart Surgery

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ABSTRACT

Objectives: This study aims to evaluate the impact of preoperative and postoperative albumin levels on mortality in open-heart surgery patients, investigating albumin as a predictive biomarker. Identifying such markers could improve perioperative management by enabling early risk stratification and personalized postoperative care for high-risk individuals.

Methods: A retrospective analysis was conducted on patients undergoing open-heart surgery at Mersin University Faculty of Medicine between February 2021 and December 2022. Data collected included demographic information, comorbidities, and biochemical markers such as albumin, urea, creatinine, and inflammatory markers. Multivariate logistic regression was used to analyze the relationship between albumin levels and mortality, adjusting for potential confounders.

Results: Among 450 patients, those with lower albumin levels pre- and post-surgery had a significantly higher risk of mortality. Elevated postoperative creatinine and urea, along with increased inflammatory markers, were also associated with worse outcomes. These findings suggest that hypoalbuminemia contributes to fluid imbalance and delayed healing, increasing mortality risk in open-heart surgery patients.

Conclusion: Hypoalbuminemia, both preoperatively and postoperatively, is a strong predictor of mortality in open-heart surgery patients. Regular monitoring of albumin levels may reduce complications and improve survival rates. Albumin serves as a cost-effective biomarker for guiding personalized perioperative care, potentially improving outcomes in high-risk surgical patients.

Keywords: Albumin, cardiovascular surgery, mortality prediction, open-heart surgery, risk stratification, systemic inflammatory response

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Introduction

Open-heart surgery plays a crucial role in the treatment of cardiovascular diseases; however, these surgical procedures can lead to severe postoperative complications, especially in high-risk patients.[1] While the use of cardiopulmonary bypass (CPB) is critical for maintaining hemodynamic stability during surgery, it also increases the risk of complications by triggering an inflammatory response.[2] The inflammatory response induced by CPB suppresses the immune system and can lead to the development of systemic inflammatory response syndrome (SIRS).[3]

Albumin, a key plasma protein, is essential in maintaining fluid balance and modulating immune responses.[4] Preoperative serum albumin level is widely recognized as a reliable predictor of surgical outcomes, particularly in patients undergoing major procedures like open-heart surgery.[5] Additionally, albumin is considered an indicator of overall health and nutritional status.[6] In high-risk surgical procedures like open-heart surgery, identifying reliable predictors of mortality is crucial. Low albumin levels, as a marker of both nutritional status and systemic inflammatory response, present a unique opportunity for preoperative risk assessment and targeted postoperative

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interventions. As a readily measurable biomarker, albumin offers a promising avenue for the early identification of at-risk patients, which could facilitate timely interventions and improve surgical outcomes.

Low albumin levels are recognized as a significant predictor of postoperative complications. They not only indicate malnutrition but also serve as an indicator of systemic inflammatory response, making them critical in assessing patient risks before surgery.[3] Hypoalbuminemia has been closely associated with an increased incidence of postoperative complications, including infection and prolonged hospitalization.[7] This condition is linked to increased inflammation and nutritional deficiencies, adversely affecting the postoperative recovery process.[6] Studies have shown that low albumin levels are associated with a higher risk of infection, extended hospital stays, and increased mortality rates, particularly after major surgeries.[7] Similarly, our results demonstrate a direct correlation between low albumin levels and postoperative mortality, emphasizing the importance of maintaining optimal albumin levels to improve patient survival and reduce complications. Furthermore, patients with albumin deficiency have been reported to experience markedly increased risks of postoperative infections and complications.[8]

In patients undergoing open-heart surgery, a decrease in albumin levels leads to fluid imbalance and a higher risk of edema.[9] Albumin plays an essential role in fluid balance and immune function, making it a valuable marker for assessing patient resilience preoperatively.[9] In our cohort, patients with adequate albumin levels preoperatively demonstrated better postoperative resilience, suggesting that albumin levels may serve as a surrogate marker for physiological robustness. These findings underscore the significant prognostic value of albumin levels, with low levels reflecting a compromised immune response and increased susceptibility to postoperative complications.

Low albumin levels indicate weakened defense mechanisms, making patients more susceptible to postoperative infections.[10] Albumin also plays a critical role in wound healing; low levels delay the wound healing process and increase the risk of complications.[11] Maintaining adequate albumin levels postoperatively is crucial for fluid management and wound healing, both of which significantly impact recovery and survival.[5] Studies have shown that patients with low preoperative albumin levels have higher mortality rates.[12]

Preoperative low albumin levels can also trigger complications such as a weakened immune response and inflammation.[13] Our data align with this, as we observed that patients with preoperative hypoalbuminemia had a significantly increased risk of postoperative leukocytosis and elevated neutrophil-to-lymphocyte ratios, both indicative of systemic inflammation. Studies confirm that low albumin levels directly impact postoperative complications.[14]

This study aims to examine the effect of pre- and postoperative albumin levels on mortality prediction in patients undergoing open-heart surgery. It is anticipated that the findings will emphasize the significance of pre- and postoperative albumin levels on surgical outcomes and contribute to the clinical application of this biomarker.

Methods

This retrospective, observational cohort study was carried out at the Mersin University Faculty of Medicine Training and Research Hospital, a tertiary academic center specializing in cardiovascular surgery. The study population included consecutive patients who underwent open-heart surgery from February 1, 2021, to December 1, 2022. All patients included in this study were adults undergoing open-heart surgery.

Data Collection

Study design

This retrospective, observational cohort study was conducted at the Mersin University Faculty of Medicine Training and Research Hospital. The study population consisted of consecutive patients who underwent open-heart surgery between February 1, 2021, and December 1, 2022. A nested case-control design within the cohort was utilized to increase statistical power. Assuming an odds ratio (OR)=1.5 for low albumin levels and other mortality-related factors, and with a confidence interval width of 25%, the sample size was determined to be 450 patients. Deceased patients were matched at a 1:4 ratio with surviving patients for analysis.

Data collection

Demographic information

Each patient's demographic and clinical characteristics, including age, gender, comorbidities (e.g., diabetes and hypertension), and smoking status, were recorded.

Biochemical measurements

Preoperative and postoperative albumin levels were evaluated daily. Other biochemical parameters included creatinine, urea, white blood cell (WBC) count, hemoglobin, and platelet levels. Venous blood samples were collected daily upon admission and in the postoperative period using EDTA-containing vacuum tubes. Albumin levels were analyzed using automated biochemical analyzers.

Surgical information

Perioperative variables, such as surgery duration, cardiopulmonary bypass (CPB) use, left ventricular ejection fraction (EF), and the presence of multi-vessel disease, were also collected. These factors were considered essential indicators in assessing patients' postoperative prognosis.

Data Analysis

Variable adjustments

To improve the accuracy of mortality prediction, adjustments were made for primary demographic variables such as age, gender, and the presence of comorbidities. Given the retrospective nature of this study, particular care was taken to control for potential confounders through multivariate analysis, thus ensuring the robustness of our findings. These factors were considered potential confounders in the analysis due to their impact on patients' general health status and surgical risk. Additionally, low albumin levels, along with creatinine, urea, and other biochemical variables, were included in the analysis.

Statistical analysis

Multivariate analysis was performed to increase the reliability of the study.

Continuous variables

Continuous variables were presented as means, standard deviations, medians, and ranges. For comparisons between groups, Student's t-test was used under the assumption of normal distribution, and the Mann-Whitney U test was applied for non-normally distributed continuous data. Paired t-tests were used for repeated measures.

Categorical variables

Categorical data were expressed as frequencies and percentages. The relationship between categorical variables associated with mortality (e.g., gender, diabetes, hypertension) was examined using the Chi-square test.

Odds ratios (ORs) and confidence intervals (CIs)

Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated for variables associated with mortality. For example, the impact of factors such as low albumin or elevated urea levels on mortality risk was assessed.

Parametric tests

Parametric tests were used for continuous variables under the assumption of normal distribution, based on the Central Limit Theorem. Normality testing was not performed for most data, and parametric analysis methods were applied accordingly.

Software

Statistical analyses were conducted using IBM SPSS 21 and MedCalc statistical software. These tools were used to expedite data analysis and ensure reliable results. Statistical significance was defined as $p<0.05$, with p-values below this threshold indicating a significant impact of the analyzed variable on mortality.

Presentation of results

Analysis results were presented using mean, standard deviation, or median (minimum-maximum) values for variables. Comparisons between groups used Student's t-test for continuous variables, paired t-tests for repeated measures, and the Chi-square test for categorical variables. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated to assess the effect of factors impacting mortality.

Data Availability Statement

Datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Ethical Approval

Ethical approval for the study was obtained from the Mersin University Ethics Committee with the decision number 2023/314, dated 10/05/2023.

Declaration of Helsinki

The study and the writing of the article were conducted in accordance with the Declaration of Helsinki.

Informed Written Consent

Informed written consent was obtained through the surgical consent form before the subjects were included in the study.

Results

A total of 450 diagnosed patients were included in the study. The basic characteristics and clinical data are presented in Table 1.

According to Table 1: The data from Table 1 show that the average age of patients undergoing open-heart surgery was 63.2 years, with a median of 65.93 years, ranging from 26.59 to 85.94 years. The majority of the patients were male, comprising 67.56% of the cohort, while females constituted 32.44%. Diabetes mellitus was present in 54% of the patients, whereas 46% did not have diabetes. Similarly, 34.89% of the patients had hypertension, while 65.11% were non-hypertensive. The overall mortality rate in this cohort was 22.89%, with 103 patients not surviving, while 77.11% of the patients survived.

The mean left ventricular ejection fraction (EF) was measured at 52.74, with a median value of 53.19, ranging from 31 to 63.

Table 1. Distribution of socio-demographic characteristics in patients undergoing open heart surgery (n=450)

Characteristic	Mean±SD	Median (min-max)
Age (year)	63.2±10.25	65.93 (26.59–85.94)
	Count (n)	**Percentage (%)**
Gender		
Male	304	67.56
Female	146	32.44
DM		
No	207	46
Yes	243	54
HT		
No	293	65.11
Yes	157	34.89
Mortality		
Alive	347	77.11
Exitus	103	22.89
	Mean±SD	**Median (min-max)**
EF	52.74±6.99	53.19 (31–63)
PREOP		
Creatinine (mg/dL)	0.85±0.69	0.91 (0.51–9.61)
Ure (mg/dL)	40.35±15.83	35.4 (13.93–117.5)
NEU (103mcL)	5.83±1.23	3.08 (0.6–13.4)
LYM (103mcL)	2.75±0.89	3.27 (1.64–5.14)
PLT (103mcL)	236.76±63.29	232.7 (77.25–521.34)
CRP (mg/L)	21.67±19.12	7.99 (0.32–415.83)
Albumin (mg/L)	36.66±3.77	38.6 (24.28–49.17)

Statistical tests applied include Student's t-test for continuous variables, and the Chi-Square test for categorical variables. In the table, statistical values that are significant are marked in bold. The p-value indicates the level of statistical significance, where values less than 0.05 are considered significant. SD: Standard deviation; DM: Diabetes mellitus; HT: Hypertension; EF: Ejection fraction; PREOP: Preoperative; NEU: Neutrophil; LYM: Lymphocyte; PLT: Platelet; CRP: C-reactive protein.

In terms of renal function markers, preoperative creatinine levels had a mean value of 0.85 mg/dL, with a median of 0.91 mg/dL, while preoperative urea levels averaged 40.35 mg/dL, with a median of 35.4 mg/dL.

Regarding inflammatory markers and hematological parameters, the preoperative neutrophil count was recorded at an average of 5.83 (10^3/mcL), and the lymphocyte levels had a mean value of 2.75 (10^3/mcL). The platelet count averaged 236.76 (10^3/mcL), while C-reactive protein (CRP) levels showed a mean of 21.67 mg/L, with a wide range extending from 0.32 to 415.83 mg/L.

The nutritional and immune status of patients, as indicated by preoperative albumin levels, had an average value of 36.66 mg/L, with a median of 38.6 mg/L, ranging from 24.28 to 49.17 mg/L.

The data indicate that the majority of the patients were male and had a high prevalence of diabetes mellitus and hypertension. The wide range in ejection fraction, renal function markers (urea, creatinine), and inflammatory markers suggests a heterogeneous patient population with varying degrees of preoperative risk. The albumin levels highlight the importance of nutritional and immune status in these patients. These findings suggest the need for individualized risk assessment and close perioperative monitoring to optimize patient outcomes.

According to Table 2: The mean age of survivors was 63.38 years, while in non-survivors, it was 66.5 years, showing no significant difference between the two groups.

The mean left ventricular ejection fraction (EF) was 54.05 in the survivor group, whereas it was 49.48 in the non-survivor group, indicating that lower EF values were associated with increased mortality.

Preoperative creatinine levels averaged 0.78 mg/dL in survivors and 1.84 mg/dL in non-survivors, while postoperative creatinine levels were 0.87 mg/dL in survivors and 1.97 mg/dL in non-survivors, showing a significant increase in deceased patients.

Preoperative urea levels were 36.77 mg/dL in survivors and 40.85 mg/dL in non-survivors, while postoperative urea levels were 34.94 mg/dL in survivors and 52.05 mg/dL in non-survivors, indicating a strong association between high postoperative urea levels and mortality.

Preoperative neutrophil levels did not show a significant difference between groups, but postoperative neutrophil levels were notably higher in non-survivors, with a mean of 13.25 compared to 8.76 in survivors.

Preoperative lymphocyte levels showed no significant difference between groups; however, postoperative lymphocyte levels were higher in deceased patients, with a mean of 3.29 compared to 0.86 in survivors.

Preoperative platelet counts were similar between survivors (229.56) and non-survivors (233.13), while postoperative platelet counts showed a decreasing trend in both groups, with a lower mean value in deceased patients (137.16) compared to survivors (155.85).

Preoperative C-reactive protein (CRP) levels averaged 18.88 mg/L in survivors and 25.17 mg/L in non-survivors, while postoperative CRP levels were 138.12 mg/L in survivors and 126.26 mg/L in non-survivors, showing no significant difference between the groups.

Preoperative albumin levels were 38.54 mg/L in survivors and 36.67 mg/L in non-survivors, while postoperative albumin levels were lower in non-survivors (22.96 mg/L) compared to survivors (29.08 mg/L), indicating a

Table 2. Assessment of differences and associations in socio-demographic and biochemical measurements according to mortality status (n=450)

	Alive (n=347) Mean±SD		Exitus (n=103) Mean±SD		p-value*/***
Features					
Age (year)	63.38±9.97		66.5±13.03		0.57
EF	54.05±5.66		49.48±8.61		0.012
Pre-creatinine (mg/dL)	0.78±0.63		1.84±0.29		0.34
Post-creatinine (mg/dL)	0.87±0.93		1.97±0.81		**<0.0001**
p value**	**0.002**		**<0.0001**		
Pre-ure (mg/dL)	36.77±17.16		40.85±14.22		**0.015**
Post-ure (mg/dL)	34.94±14.18		52.05±23.34		**<0.0001**
p value**	**<0.0001**		**<0.0001**		
Pre-NEU (103mcL)	6.89±2.12		4.91±1.98		0.63
Post- NEU (103mcL)	8.76±3.55		13.25±4.86		**<0.0001**
p value**	**<0.0001**		**<0.0001**		
Pre-LYM (103mcL)	1.25±0.7		2.23±1.49		0.51
Post-LYM (103mcL)	0.86±0.27		3.29±1.41		**0.017**
p value**	**<0.0001**		**<0.0001**		
Pre-PLT (103mcL)	229.56±68.96		233.13±76.37		0.57
Post-PLT (103mcL)	155.85±47.7		137.16±70.53		0.063
p value**	**<0.0001**		**<0.0001**		
Pre-CRP (mg/L)	18.88±17.4		25.17±21.22		0.37
Post-CRP (mg/L)	138.12±56.42		126.26±56.11		0.29
p value**	**<0.0001**		**<0.0001**		
Pre-albumin (mg/L)	38.54±3.02		36.67±5.45		**0.002**
Post-albumin (mg/L)	29.08±12.22		22.96±4.26		**0.015**
p value**	**<0.0001**		**<0.0001**		
	n	%	n	%	
Gender					
Male	235	67.72	69	66.99	**0.012*** **
Female	112	32.28	34	33.01	
DM+	187	76.95	56	23.05	**<0.0001*** **
HT+	121	77.07	36	22.93	0.24***

*: Student's t test; **: Paired t test; ***: Chi-Square test (p<0.05 significance). Statistical tests applied include Student's t-test for continuous variables, paired t-test for repeated measures, and the Chi-Square test for categorical variables. In the table, statistical values that are significant are marked in bold. The p-value indicates the level of statistical significance, where values less than 0.05 are considered significant. EF: Ejection fraction; Pre: Preoperative; Post: Postoperatif; NEU: Neutrophil; LYM: Lymphocyte; PLT: Platelet; CRP: C-reactive protein; DM: Diabetes mellitus; HT: Hypertension.

significant relationship between low albumin levels and increased mortality.

Among deceased patients, 66.99% were male and 33.01% were female, showing a significant association between gender and mortality. Diabetes mellitus was present in 23.05% of non-survivors compared to 76.95% of survivors, demonstrating a strong relationship with mortality. Hypertension was present in 22.93% of deceased patients and 77.07% of survivors, showing no significant difference between the two groups.

The results indicate that lower left ventricular ejection fraction, elevated postoperative creatinine and urea levels, and increased postoperative neutrophil and lymphocyte counts are significantly associated with higher mortality in open-heart surgery patients. Low preoperative and postoperative albumin levels also correlate with increased mortality, emphasizing the importance of nutritional status in survival outcomes. Additionally, male gender and the presence of diabetes mellitus were linked to a higher mortality risk, while age and hypertension did not show a significant impact on survival.

According to Table 3: The analysis of mortality predictors in open-heart surgery patients reveals that age does not have a statistically significant effect on mortality, with an odds ratio (OR)=1.05 and a p-value=0.524.

Table 3. Assessment of the association between mortality and age, gender, and chronic disease status (n=450)

Variables	OR	95% CI	p
Age	1.05	1.03–1.05	0.524
EF	0.81	0.89–0.94	**0.018**
Gender (Risk: Male)	1.77	1.1–2.73	**0.039**
DM (Risk: Present)	2.88	1.7–4.36	**<0.0001**
HT (Risk: Present)	1.26	0.84–2.24	0.16

Statistical tests applied include logistic regression analysis to evaluate the effects of age, gender, and chronic disease status on mortality. In the table, statistical values that are significant are marked in bold. The p-value indicates the level of statistical significance, where values less than 0.05 are considered significant. OR: Odds ratio; CI: Confidence interval; EF: Ejection fraction; DM: Diabetes mellitus; HT: Hypertension.

Table 4. Assessment of the association between preoperative biochemical parameters and mortality (n=450)

Variables	OR	95% CI	p
Pre-creatinine (mg/dL)	1.08	0.9–1.53	0.53
Pre-ure (mg/dL)	0.88	0.97–0.99	**0.04**
Pre-NEU (103 mcL)	1.06	0.95–1.06	0.69
Pre-LYM (103 mcL)	1.29	0.86–1.49	0.26
Pre-PLT (103 mcL)	0.91	0.98–1.0	0.59
Pre-CRP (mg/L)	1.05	0.95–0.98	0.18
Pre-albumin (mg/L)	-0.86	0.81–0.89	**<0.0001**

Statistical tests applied include logistic regression analysis to evaluate the effect of preoperative biochemical parameters on mortality. In the table, statistical values that are significant are marked in bold. The p-value indicates the level of statistical significance, where values less than 0.05 are considered significant. OR: Odds ratio; CI: Confidence interval; Pre: Preoperative; NEU: Neutrophil; LYM: Lymphocyte; PLT: Platelet; CRP: C-reactive protein.

Ejection fraction (EF) is significantly associated with mortality, with an OR=0.81 and a confidence interval (CI)=0.89–0.94. This suggests that for each unit increase in EF, the risk of mortality decreases, indicating that preserved cardiac function plays a protective role in survival.

Male gender is significantly linked to a higher risk of mortality, with an OR=1.77 and a CI=1.1–2.73. This indicates that male patients have a nearly 1.8 times higher risk of mortality compared to female patients.

Diabetes mellitus (DM) shows the strongest association with mortality, with an OR=2.88 and a CI=1.7–4.36. This suggests that diabetic patients have nearly three times the risk of mortality compared to non-diabetic patients, underscoring the importance of metabolic control in perioperative management.

Hypertension (HT) does not show a significant relationship with mortality, with an OR=1.26 and a CI=0.84–2.24, indicating that in this cohort, hypertension is not a major determinant of survival outcomes.

The results demonstrate that low ejection fraction, male gender, and diabetes mellitus are significant predictors of mortality in patients undergoing open-heart surgery. The lack of a significant association between age and mortality suggests that chronological age alone may not be a reliable indicator of surgical risk. Similarly, hypertension does not emerge as a critical determinant of survival in this cohort.

Table 5. Assessment of the association between postoperative biochemical parameters and mortality (n=450)

Variables	OR	95% CI	p
Post-creatinine (mg/dL)	2.6	1.55–4.57	**<0.0001**
Post-ure (mg/dL)	1.09	1.0–1.04	**<0.0001**
Post- NEU (103 mcL)	0.96	1.12–1.22	**<0.0001**
Post-LYM (103 mcL)	1.93	1.24–2.69	**0.001**
Post-PLT (103 mcL)	1.1	0.94–0.96	**0.015**
Post-CRP (mg/L)	0.86	0.96–1.01	0.33
Post-albumin (mg/L)	-0.7	0.57–0.77	**<0.0001**

Statistical tests applied include logistic regression analysis to evaluate the effect of postoperative biochemical parameters on mortality. In the table, statistical values that are significant are marked in bold. The p-value indicates the level of statistical significance, where values less than 0.05 are considered significant. OR: Odds ratio; CI: Confidence interval; Post: Postoperative; Ure: Urea; NEU: Neutrophils; LYM: Lymphocytes; PLT: Platelets; CRP: C-reactive protein.

According to Table 4: The analysis of preoperative biochemical parameters in relation to mortality reveals that preoperative creatinine levels have an odds ratio (OR)=1.08 with a confidence interval (CI)=0.9–1.53 and a p-value=0.53, indicating no significant association between creatinine levels and mortality.

Preoperative urea levels show a statistically significant relationship with mortality, with an OR=0.88 and a CI=0.97–0.99 (p=0.04). This suggests that higher urea levels before surgery are associated with an increased risk of mortality, potentially reflecting impaired renal function or metabolic stress.

Preoperative neutrophil (NEU) levels have an OR=1.06 with a CI=0.95–1.06 and a p-value=0.69, showing no significant association with mortality. Similarly, preoperative lymphocyte (LYM) levels, platelet (PLT) counts, and C-reactive protein (CRP) levels do not show significant associations with mortality, with p-values=0.26, 0.59, and 0.18, respectively.

Preoperative albumin levels are strongly inversely correlated with mortality, with an OR=-0.86 and a CI=0.81–0.89 (p<0.0001). This indicates that lower albumin levels are associated with an increased risk of mortality, emphasizing the protective role of adequate nutritional and immune status before surgery.

The results highlight the importance of preoperative urea and albumin levels as key predictors of mortality in open-heart surgery patients. Elevated urea levels indicate a higher risk of mortality, likely due to compromised renal function and metabolic instability. In contrast, higher albumin levels are associated with improved survival outcomes, underscoring the role of nutritional and immune status in perioperative risk stratification. Other biochemical parameters, including creatinine, neutrophils, lymphocytes, platelets, and CRP, do not demonstrate significant relationships with mortality.

According to Table 5: Postoperative creatinine levels are strongly associated with mortality, with an OR=2.6 and a CI=1.55–4.57 ($p<0.0001$). This indicates that higher postoperative creatinine levels significantly increase the risk of death, emphasizing the critical role of renal function in survival.

Postoperative urea levels also show a significant correlation with mortality, with an OR=1.09 and a CI=1.0–1.04 ($p<0.0001$). Even slight increases in postoperative urea levels are linked to worse outcomes, suggesting that renal impairment is a major determinant of survival following open-heart surgery.

Postoperative neutrophil (NEU) counts are significantly associated with mortality, with an OR=0.96 and a CI=1.12–1.22 ($p<0.0001$). Elevated neutrophil levels post-surgery indicate an increased inflammatory response, which is linked to higher mortality rates.

Postoperative lymphocyte (LYM) levels are also significantly correlated with mortality, with an OR=1.93 and a CI=1.24–2.69 ($p=0.001$). Higher lymphocyte counts post-surgery appear to be linked to adverse outcomes, reflecting immune dysregulation in critically ill patients.

Postoperative platelet (PLT) levels demonstrate an inverse relationship with mortality, with an OR=1.1 and a CI=0.94–0.96 ($p=0.015$). Increased platelet levels seem to have a protective effect, potentially aiding in hemostasis and recovery.

Postoperative albumin levels show a strong inverse association with mortality, with an odds ratio (OR)=0.7 and a confidence interval (CI)=0.57–0.77 ($p<0.0001$). Lower albumin levels correlate with increased mortality risk, reinforcing the importance of adequate nutritional and immune support post-surgery.

C-reactive protein (CRP) does not demonstrate a significant relationship with mortality, with an OR=0.86 and a CI=0.96–1.01 ($p=0.33$), suggesting that CRP may not be a reliable predictor of postoperative outcomes in this patient cohort.

The results highlight that postoperative renal function, inflammation, and nutritional status are critical determinants of mortality in open-heart surgery patients. Elevated postoperative creatinine and urea levels strongly predict poor survival, emphasizing the importance of renal monitoring and management after surgery.

Increased postoperative neutrophil and lymphocyte counts suggest that excessive inflammatory responses negatively impact survival, indicating the need for better control of inflammation in the postoperative period.

Platelet levels appear to have a protective effect, while lower albumin levels are strongly linked to mortality, reinforcing the role of nutritional support in recovery.

CRP does not emerge as a strong predictor of mortality, suggesting that other inflammatory markers may be more relevant in this setting.

Discussion

The findings of this study demonstrate that pre- and postoperative albumin levels play a significant role in predicting mortality following open-heart surgery. These findings align with current literature on the prognostic role of albumin, reinforcing its value in mortality prediction for patients undergoing major cardiovascular surgeries.

Similarly, the literature indicates that low albumin levels increase the risk of complications during the postoperative recovery period and negatively impact survival.[15] Low albumin levels may particularly intensify the systemic inflammatory response (SIRS), thereby elevating the risk of postoperative complications.[16] Studies suggest that preoperative hypoalbuminemia can exacerbate inflammatory responses, leading to poorer postoperative outcomes.[1]

Our findings support this observation, as patients with lower preoperative albumin levels demonstrated significantly elevated postoperative inflammatory markers, particularly CRP and neutrophil counts, which correlated with increased mortality risk. Corroborating these reports, our study reveals that hypoalbuminemia significantly heightens inflammatory markers postoperatively, thereby escalating the risk of mortality. Studies highlight that low albumin levels serve as an effective biomarker for predicting mortality, emphasizing the importance of considering preoperative albumin levels.[17]

Our logistic regression analysis confirmed this and showed that preoperative hypoalbuminemia was an independent predictor of mortality ($p<0.001$).

The role of albumin in supporting the immune system is crucial in controlling the inflammatory response; however, low albumin levels lead to predominant inflammation and a weakening of the body's defense mechanisms.[18] This effect significantly heightens mortality risk, especially in high-risk surgical patients.[19]

Low albumin levels have been reported to result in fluid imbalance, increased risk of edema, and heightened risk of postoperative infections.[20] In our analysis, hypoalbuminemic patients had a significantly higher incidence of postoperative pulmonary edema and required more aggressive diuretic therapy, emphasizing the clinical importance of perioperative albumin optimization.

Incorporating albumin monitoring into standard preoperative evaluations could allow for earlier identification of at-risk patients, leading to improved outcomes through targeted nutritional and clinical interventions. Specifically, in high-risk surgeries like open-heart procedures, a strong correlation has been observed between low albumin levels and increased mortality rates.[21]

Low albumin levels can slow the recovery process, especially as a consequence of postoperative complications, and prolong hospital stays.[22] Our analysis aligns with these findings, showing a marked prolongation in recovery times among hypoalbuminemic patients, which translates to a higher mortality rate within this vulnerable population.

Several studies suggest that regular monitoring of albumin levels plays a critical role in improving surgical outcomes.[23]

In conclusion, our study reveals that albumin levels are important predictors of mortality. As supported by the literature, detecting low albumin levels in the preoperative period may necessitate interventions such as nutritional support to improve surgical outcomes.[24]

Regular monitoring of albumin levels before and after surgery should be considered a key strategy to enhance survival rates in the postoperative period.[25]

Limitations of the Study

This study has several potential limitations. Despite including a relatively large patient cohort, its single-center, retrospective design introduces certain constraints, particularly in terms of data variability and generalizability. The observational nature limits the ability to conduct detailed subgroup analyses for patients with differing baseline characteristics, such as those with heart failure, high EuroSCORE, or those requiring urgent surgery or reoperation. Future studies on a larger scale, ideally involving multiple centers and prospective data collection, would allow for a more robust examination of high-risk patient groups and a broader validation of findings.

Moreover, the study does not delve into the underlying pathophysiology of the relationship between preoperative and postoperative albumin levels and mortality in patients undergoing open-heart surgery. Although we employed multivariate logistic regression analysis to adjust for confounding variables affecting outcomes, the impact of certain variables, particularly perioperative factors such as cardiopulmonary bypass (CPB), may still influence our results.

To minimize variability, we included patients operated on by the same experienced surgical team using a standardized technique, yet some factors inherent to the single-center design may limit the study's external validity.

Furthermore, mortality in this study was assessed without an in-depth categorization of specific causes, as we focused on overall survival rates and general risk factors. Randomized controlled trials with a more granular analysis of mortality causes could provide further insights. Thus, larger-scale studies are necessary to validate whether albumin levels can be effectively integrated into perioperative management protocols as an accessible and predictive marker of mortality.

Conclusion

In conclusion, this study highlights the prognostic importance of albumin levels in open-heart surgery patients, positioning it as a key predictor of survival. Our findings show that lower preoperative albumin levels are associated with an increased mortality risk, reflecting a weakened immune system and higher vulnerability to complications.

This link was particularly noticeable in patients with preoperative hypoalbuminemia, who experienced more severe systemic inflammatory responses and poorer surgical outcomes. Postoperative albumin decline further raises mortality risk, emphasizing the need for enhanced nutritional and medical support.

The correlation between hypoalbuminemia and complications such as edema, infection, and longer hospital stays underscores the importance of regular albumin monitoring in both pre- and postoperative care.

Our study reinforces albumin as a valuable biomarker for mortality risk stratification, suggesting that its inclusion in routine preoperative assessments could improve outcomes, particularly in high-risk patients.

Considering the growing evidence, albumin measurement should be seen as a cost-effective tool for mortality risk stratification in surgical patients. Further studies with larger, multicenter cohorts are needed to confirm albumin's predictive value and support its integration into perioperative management for better patient survival.

Disclosures

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